Enhancing Strength and Reducing Porosity with Nucleation Seeding

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I bet he's thinking about other women
I wonder what can I do about the early strength of my low-carbon concrete?
imgflip.com

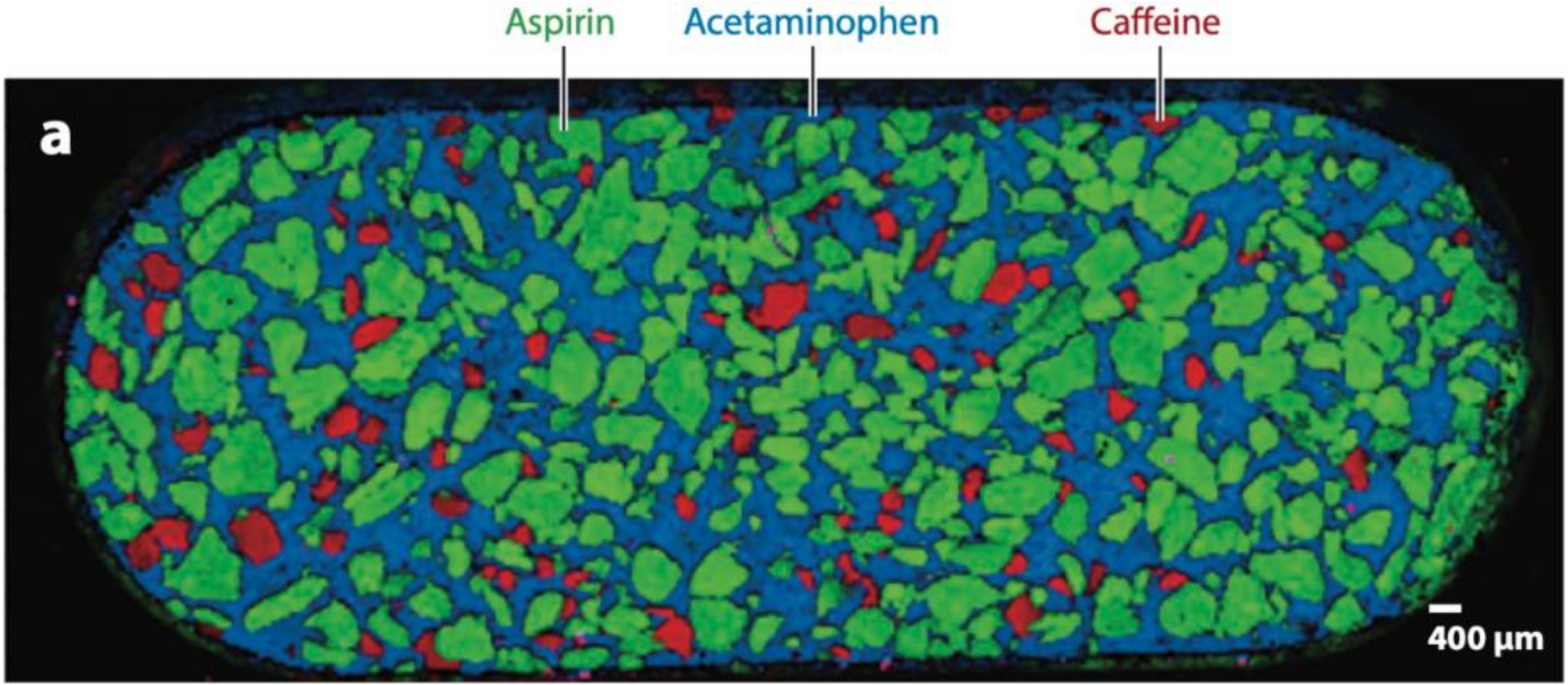
Macro

Micro

Nano

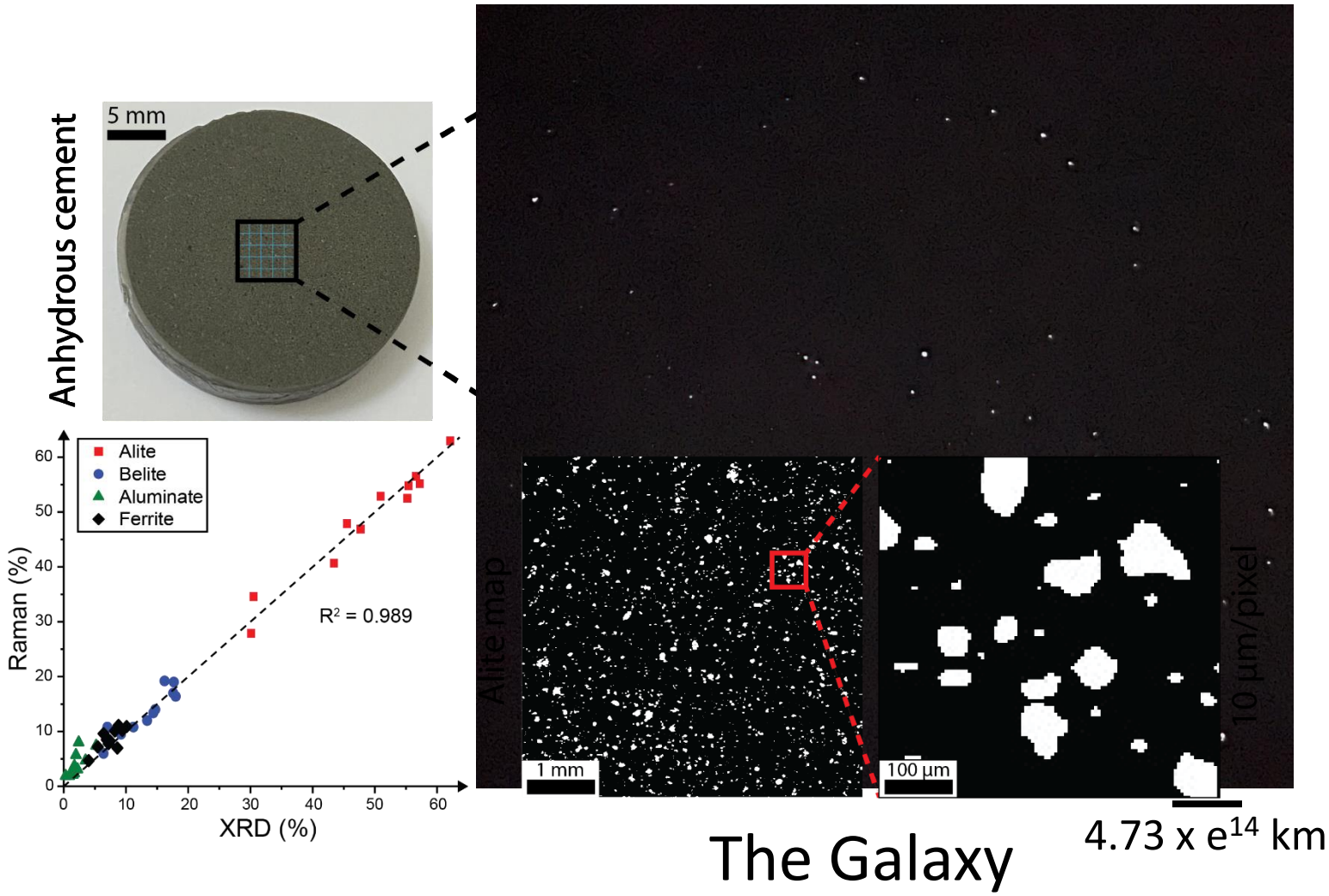
?

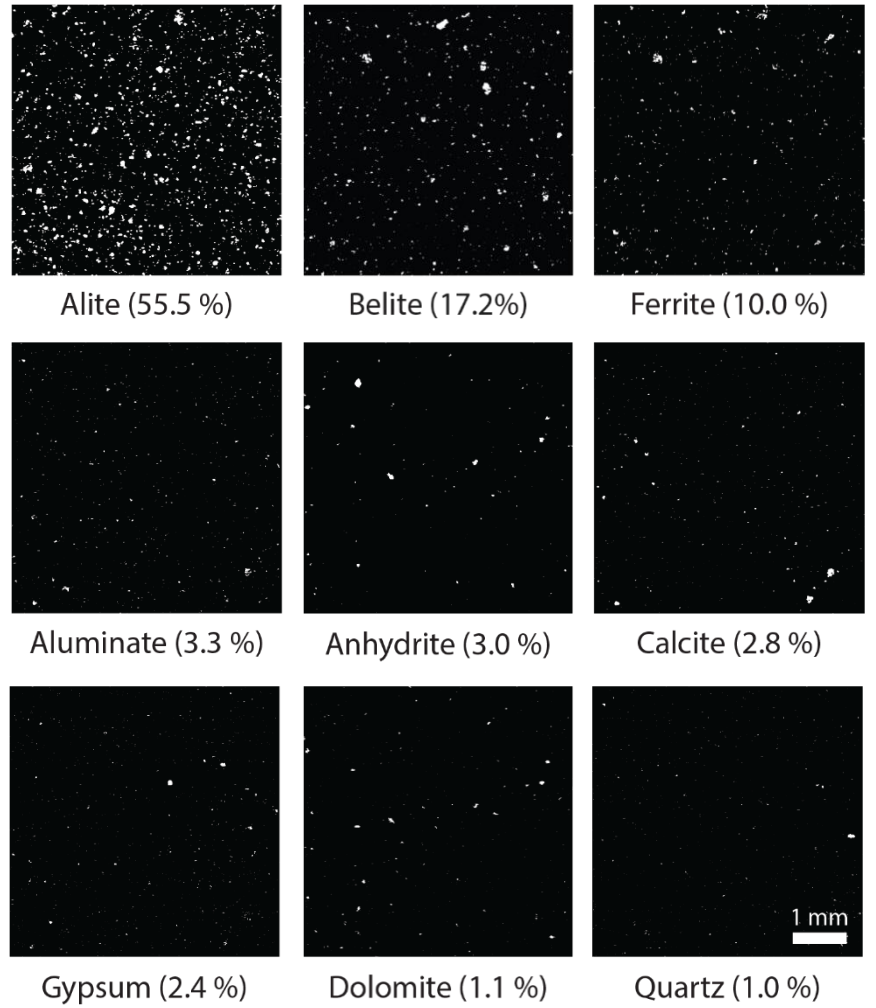
Raman Imaging for phase mapping of composite materials



Stewart et al., *Ann. Rev. Anal. Chem.* **2012**

Ordinary Portland Cement – Raman Imaging Results



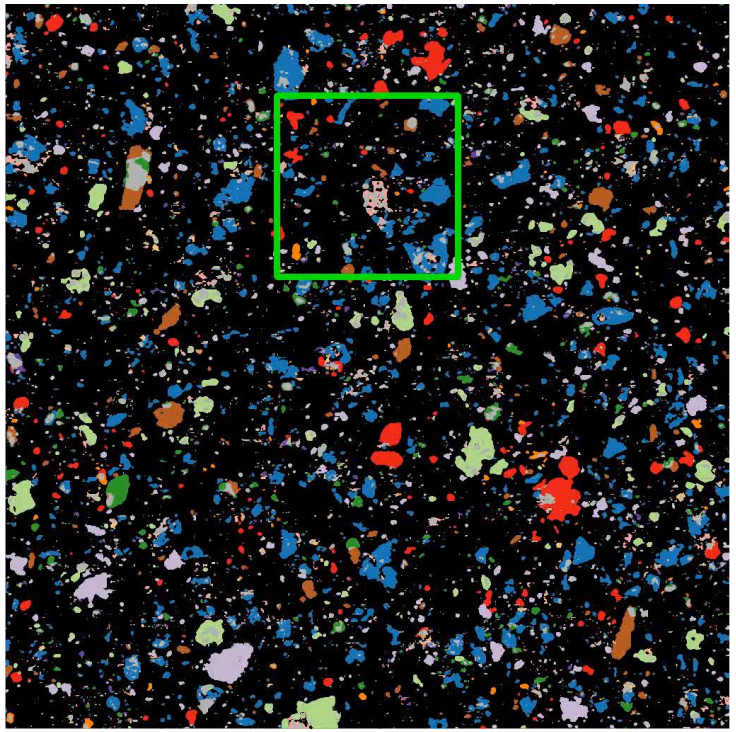


Polavaram and Garg, *Cem. Concr. Res.* **2021**

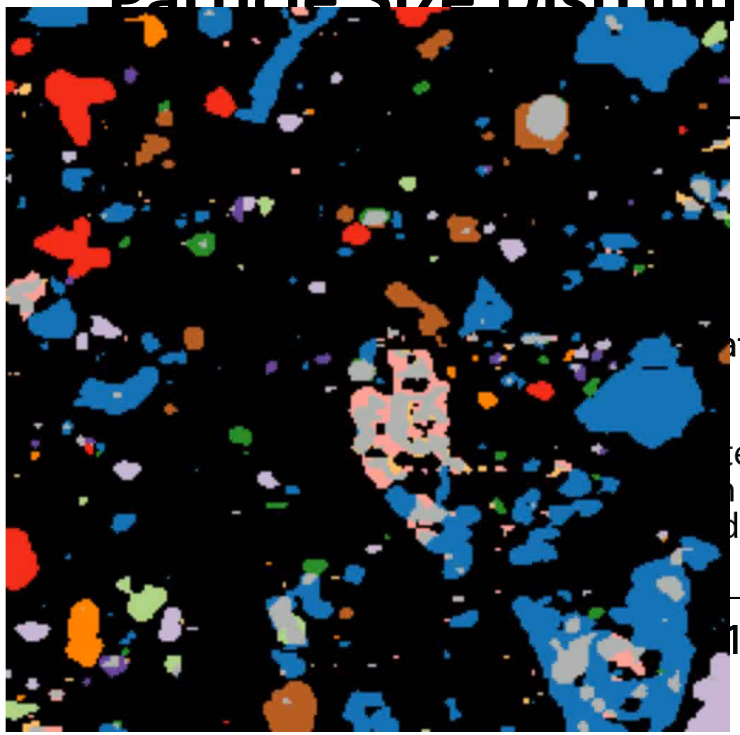
Size and Shape Distribution of **Individual** Clinker Phases

Raman Image — **Raman Image - Inset** — ***Phase-Specific* Particle Size Distributions**

Anhydrous Cement

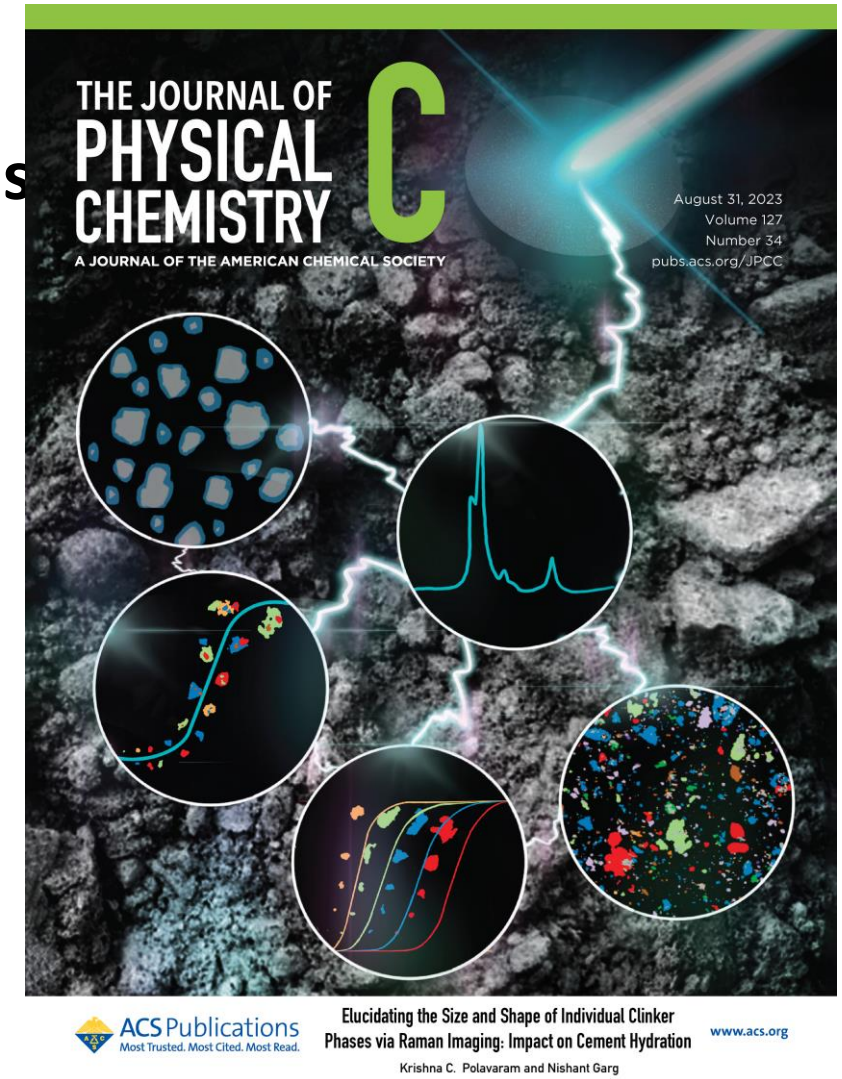


100 µm

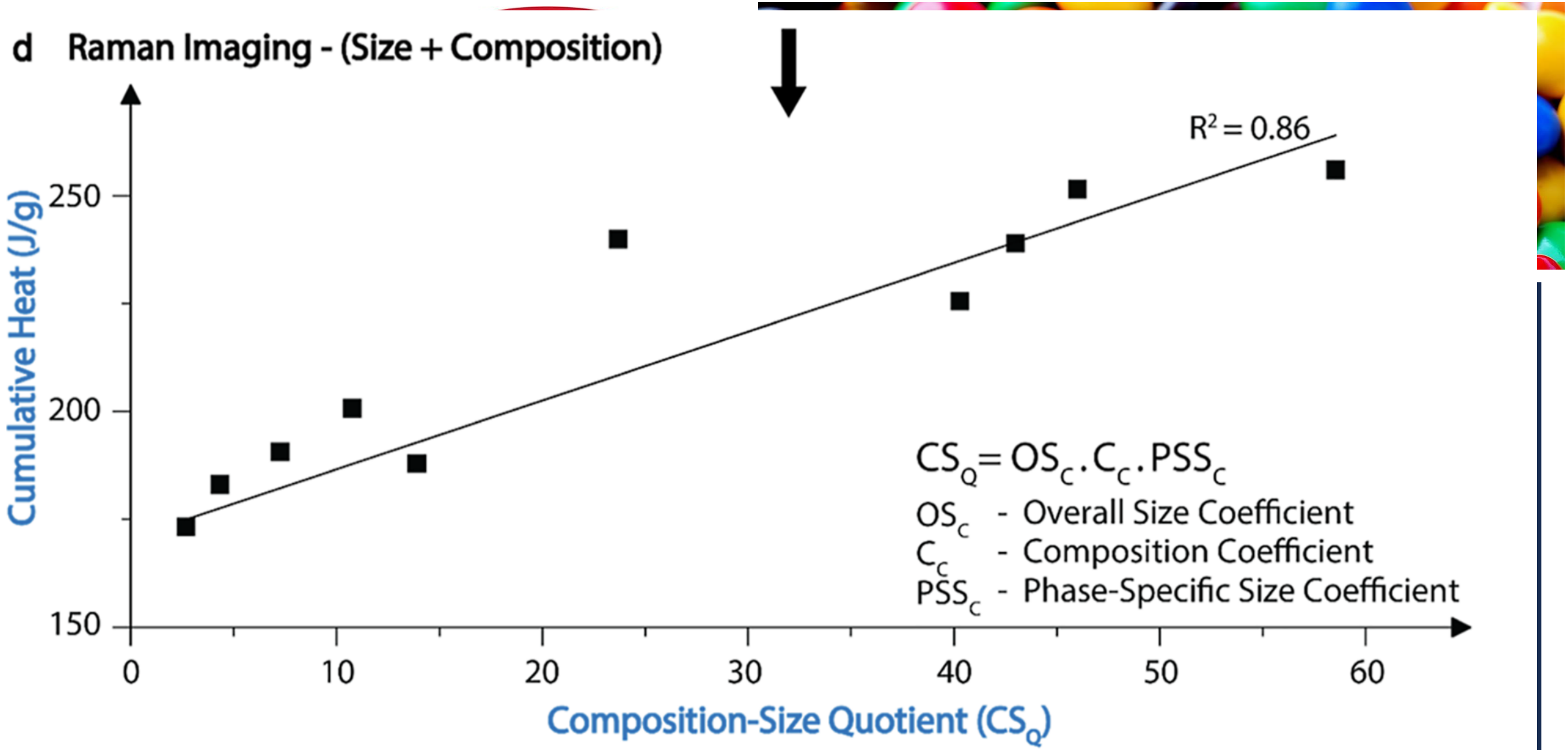


10 µm

Alite | Belite | Ferrite | Aluminate
Bassanite | Calcite | Gypsum | Syngenite
Portlandite | Quartz | Overlap | Unassigned



Polavaram and Garg, *J. Phys. Chem. C.* **2023**



Polavaram and Garg, *J. Phys. Chem. C.* **2023**

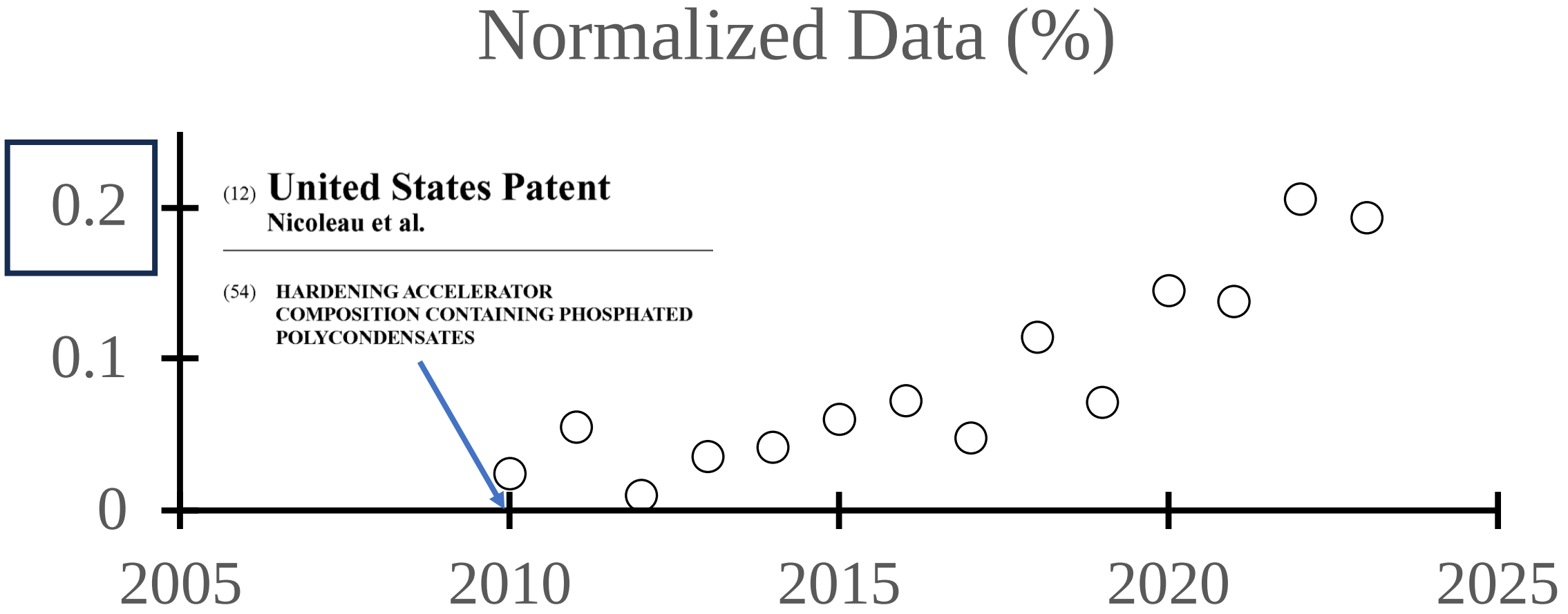
Macro

Micro

Nano

?

C-S-H Seeds – Prevalence in Literature



Research Objectives:

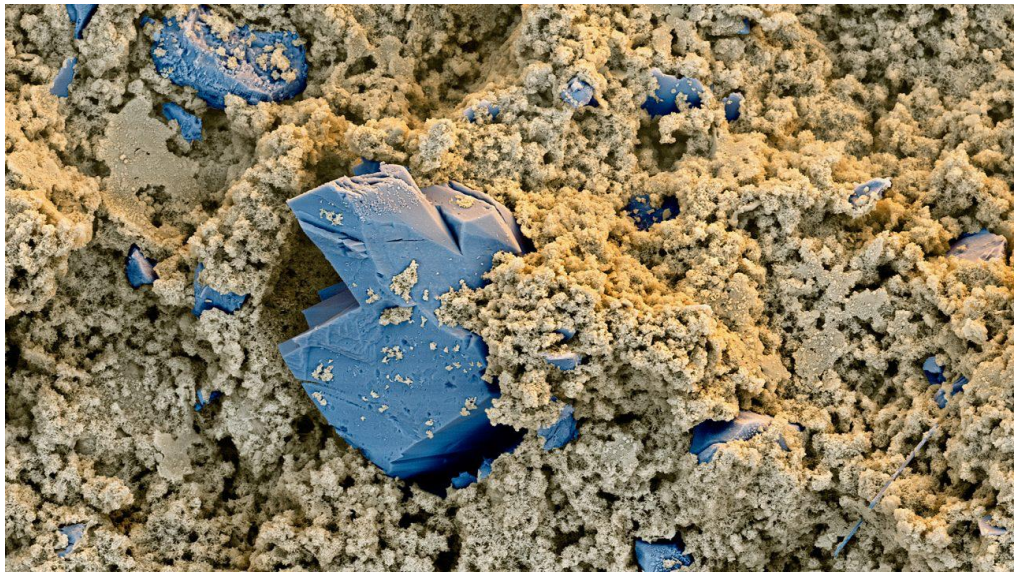
1) How do commercial C-S-H seeds influence hydration kinetics?

2) What's their impact on strength as well as porosity?

3) What new insights can be obtained via systematic microstructural investigations?

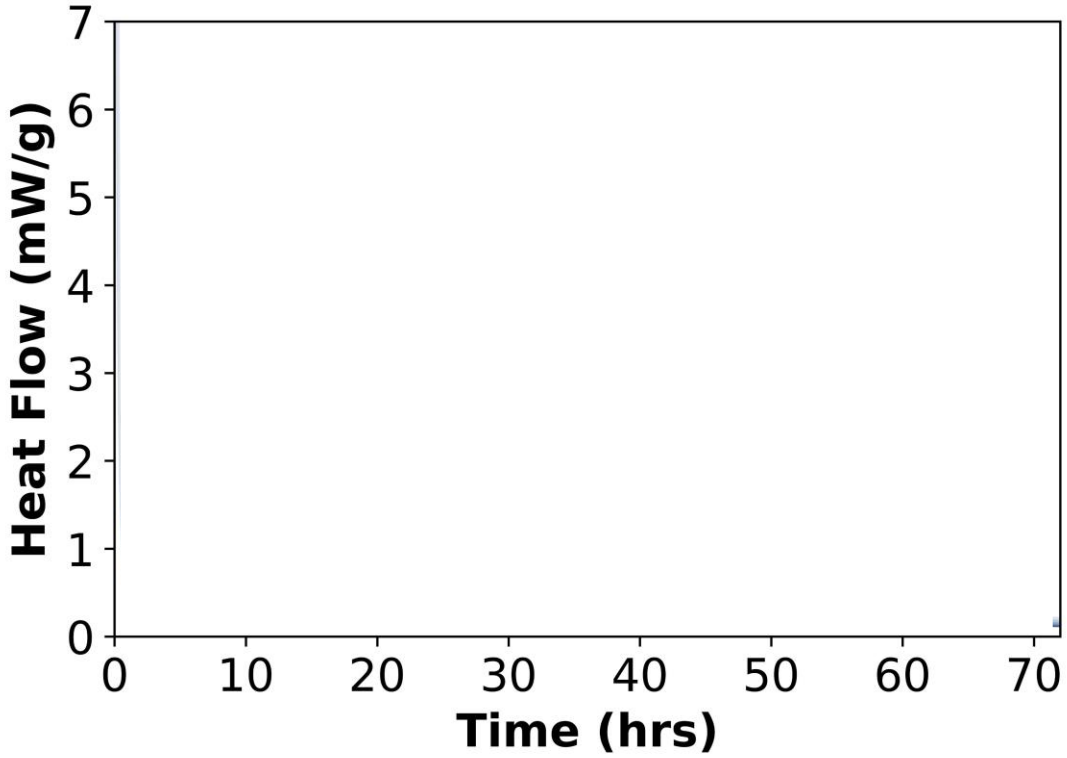
Master X-Seed®

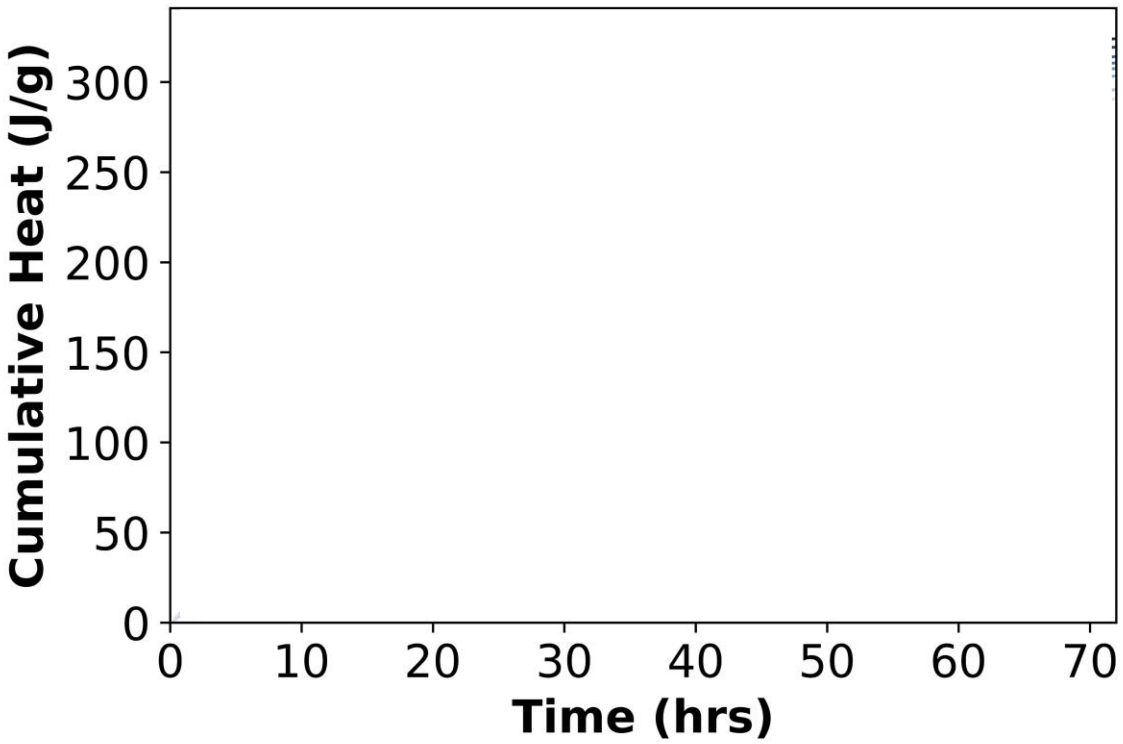
A commercial hardening accelerator from Master Builders



Materials and Methods

Kinetics – Isothermal calorimetry



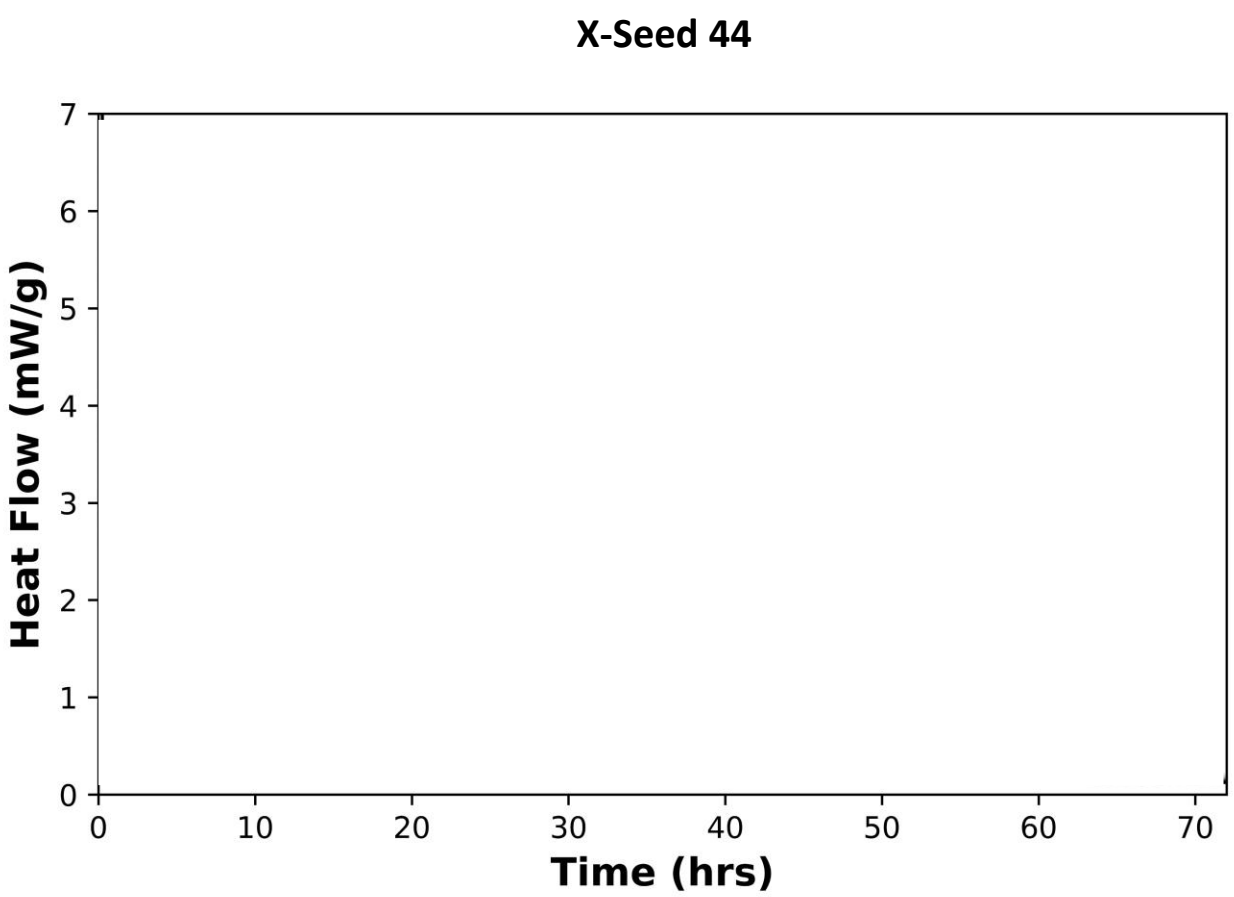


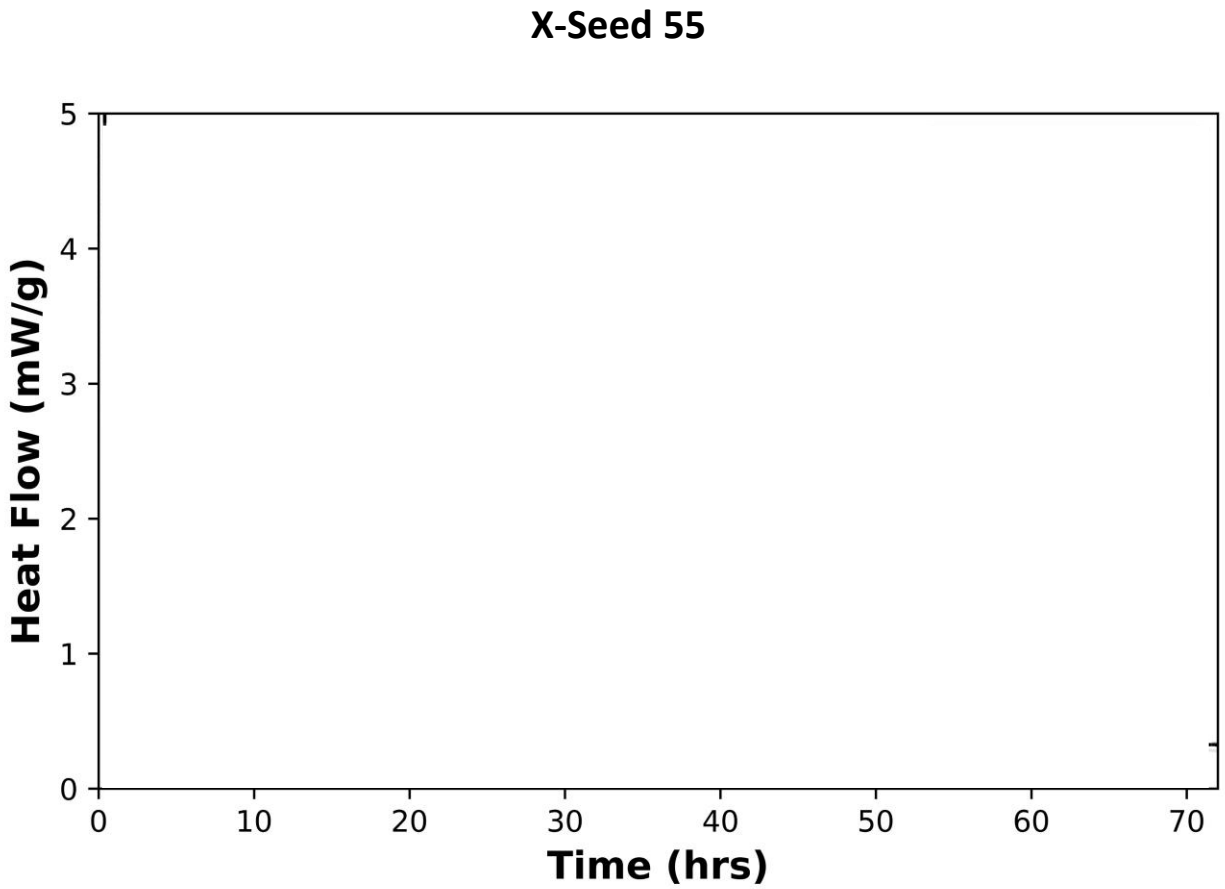
- Acceleration takes place

- Increases the degree of hydration

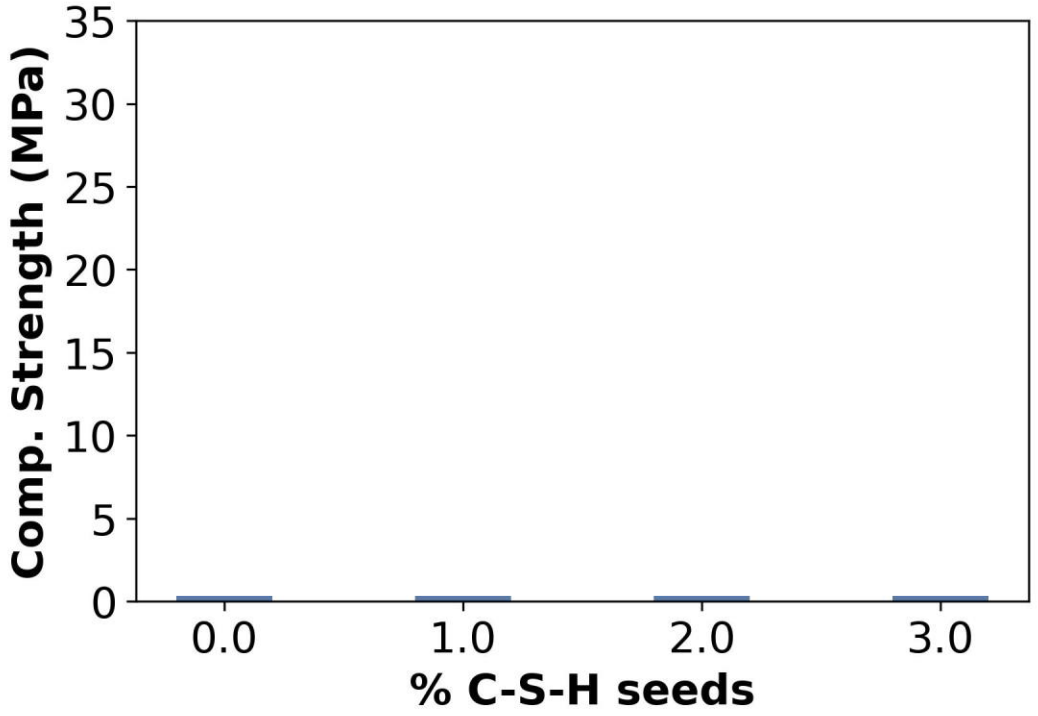
Qadri et al., *Mat. Today Com.* **2024**

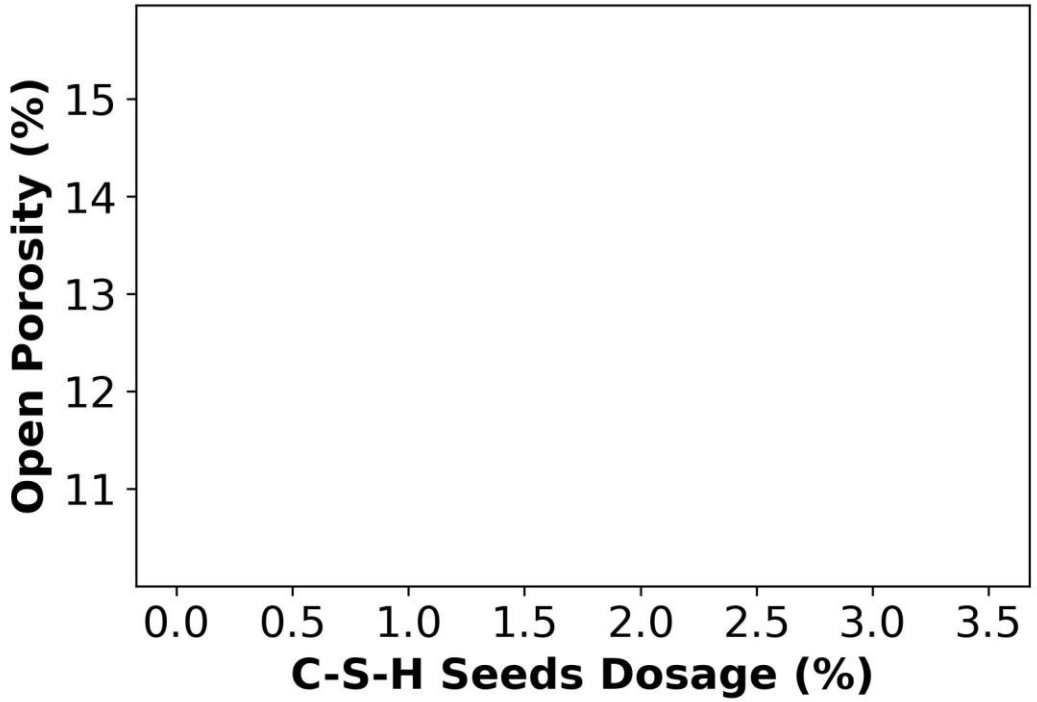
A tale of two admixtures





Enhancement in strength and open porosity





With C-S-H seeds:

- Strength increases
- Open porosity decreases

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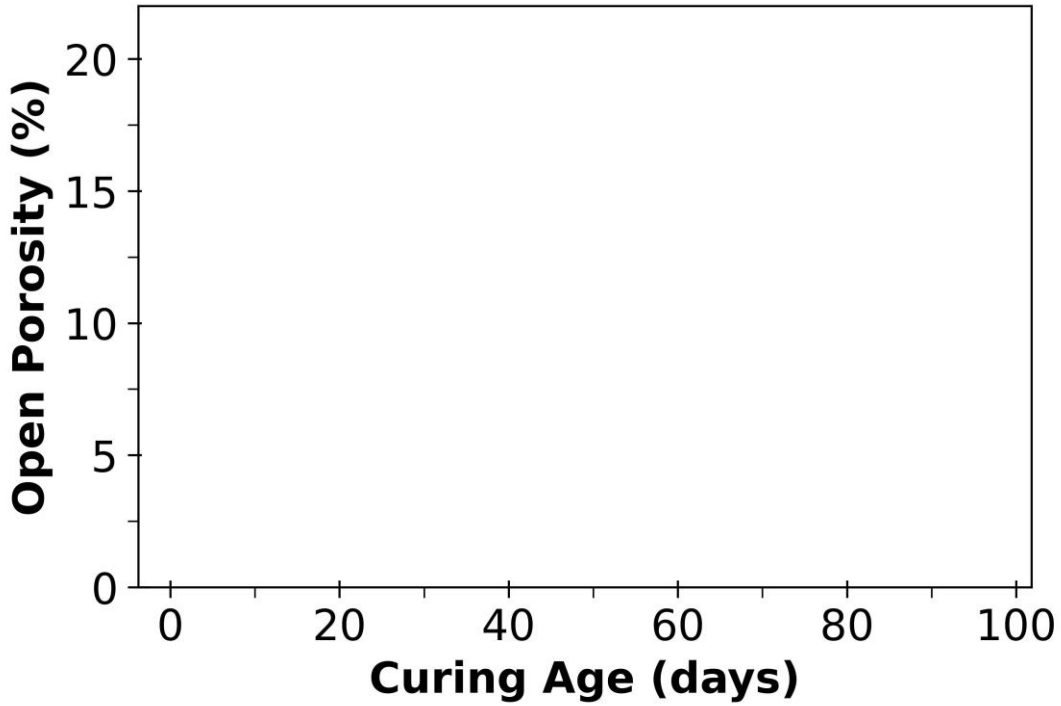
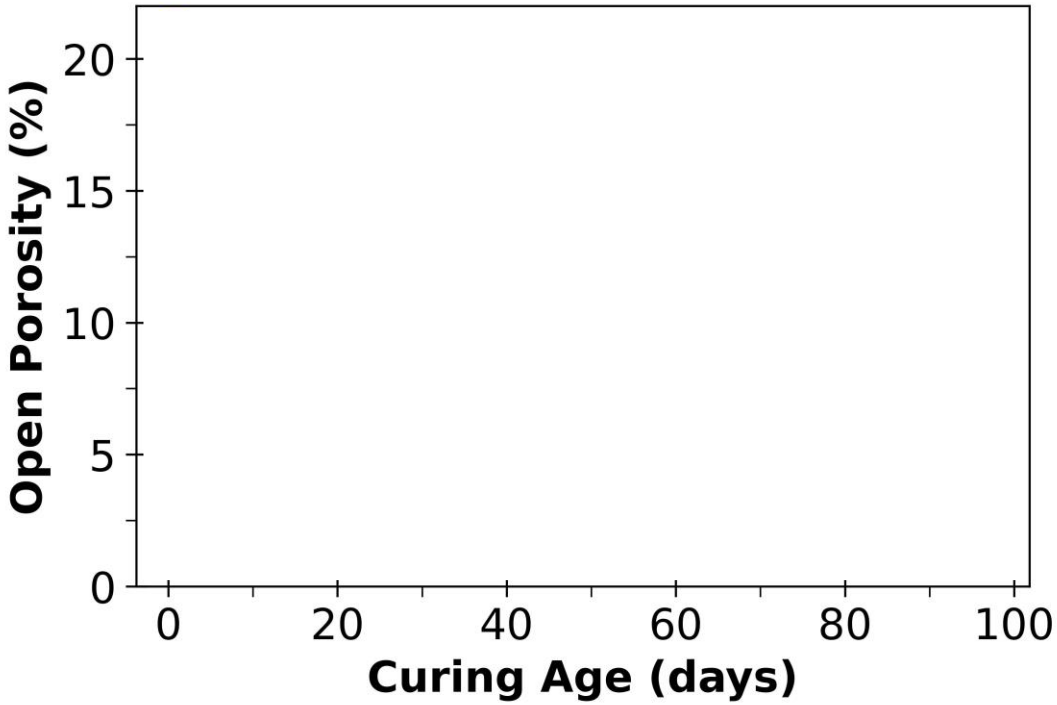
Microstructure refinement – blended cement

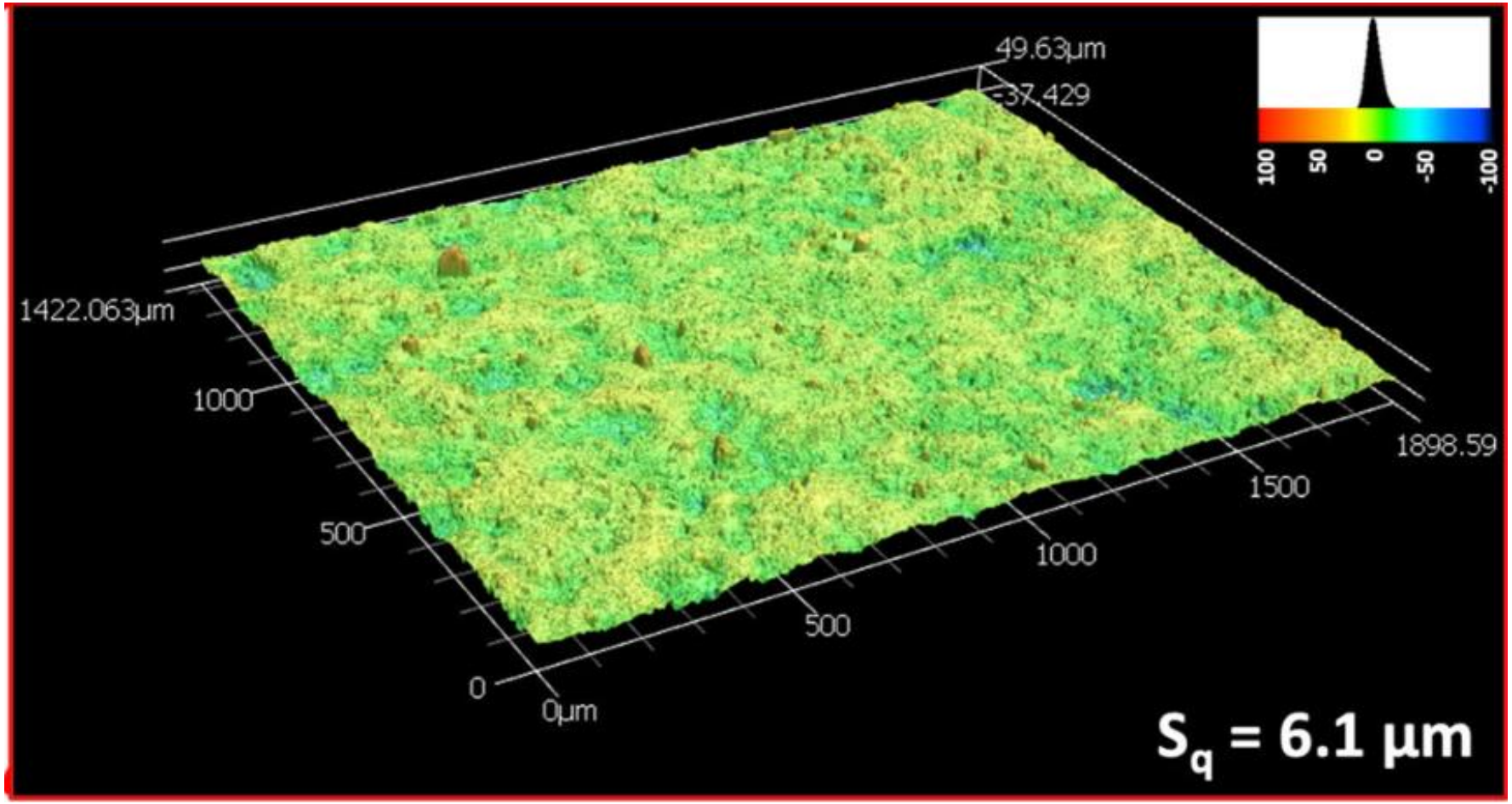




Porosity decreases at all ages

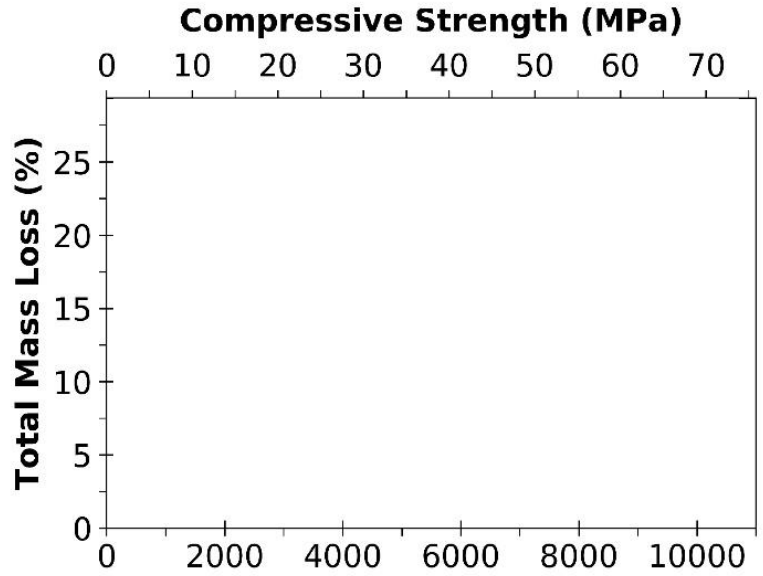
Qadri and Garg., *FHWA-ICT* **2023**

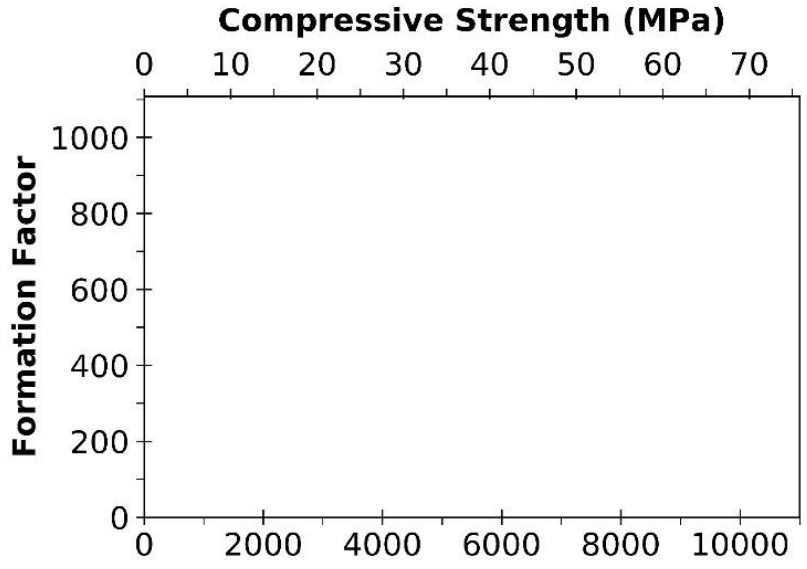
Microstructure refinement – surface roughness via Laser Profilometry



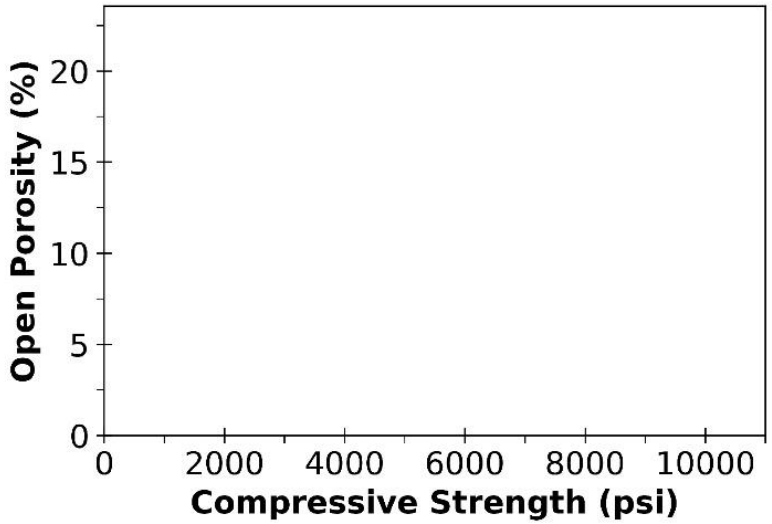
Qadri et al., *Mat. Today Com.* **2024**
Kabir & Garg, npj *Mat. Deg.* **2023**

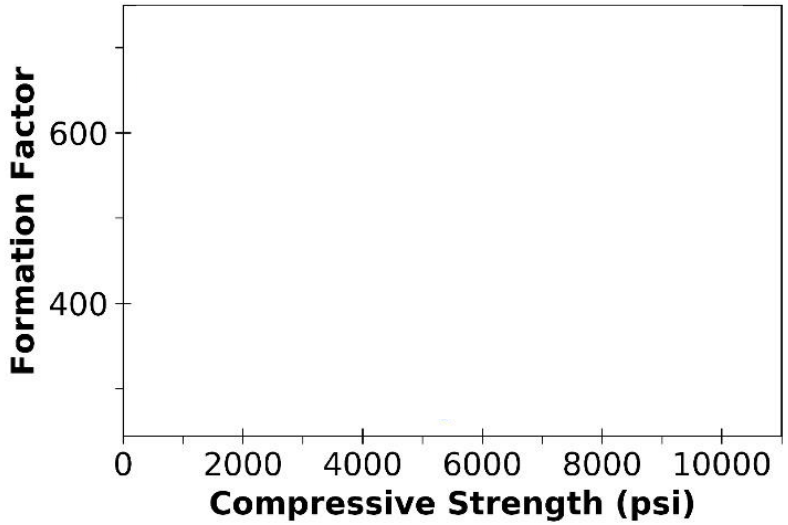
Correlations





From the lab



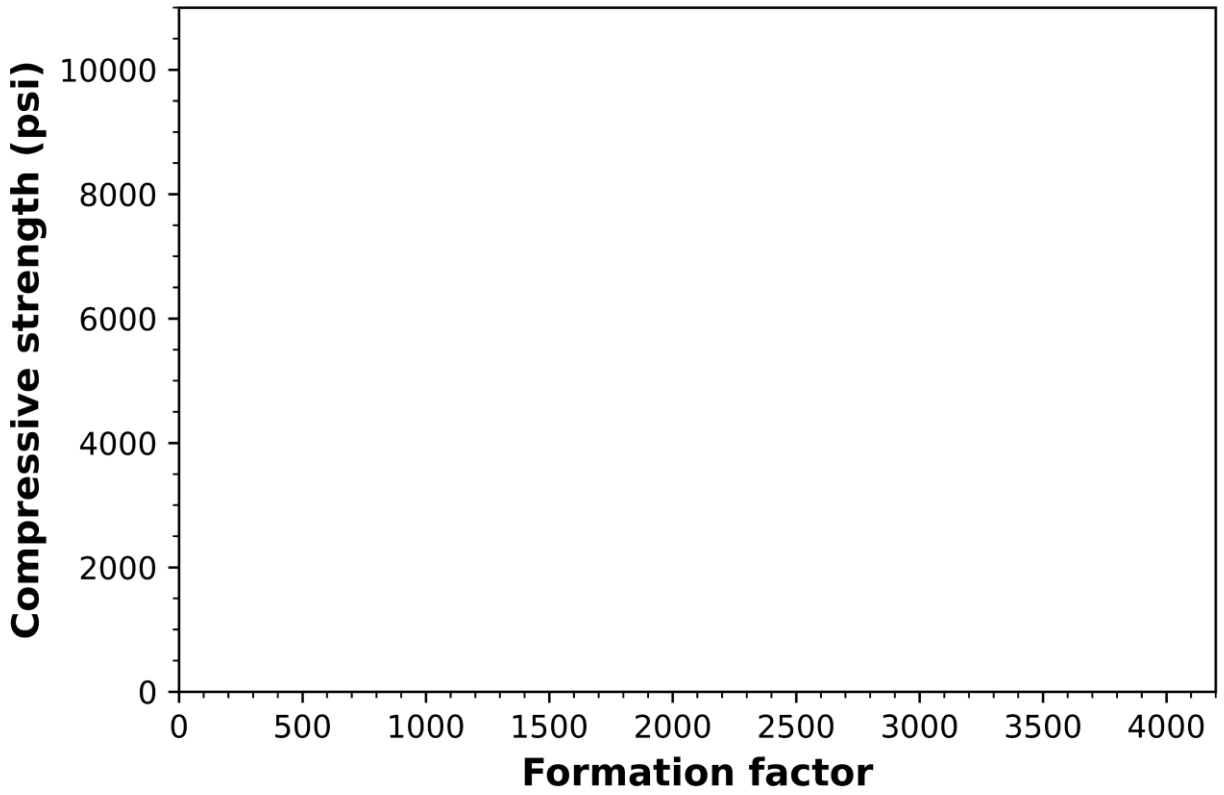


From the field

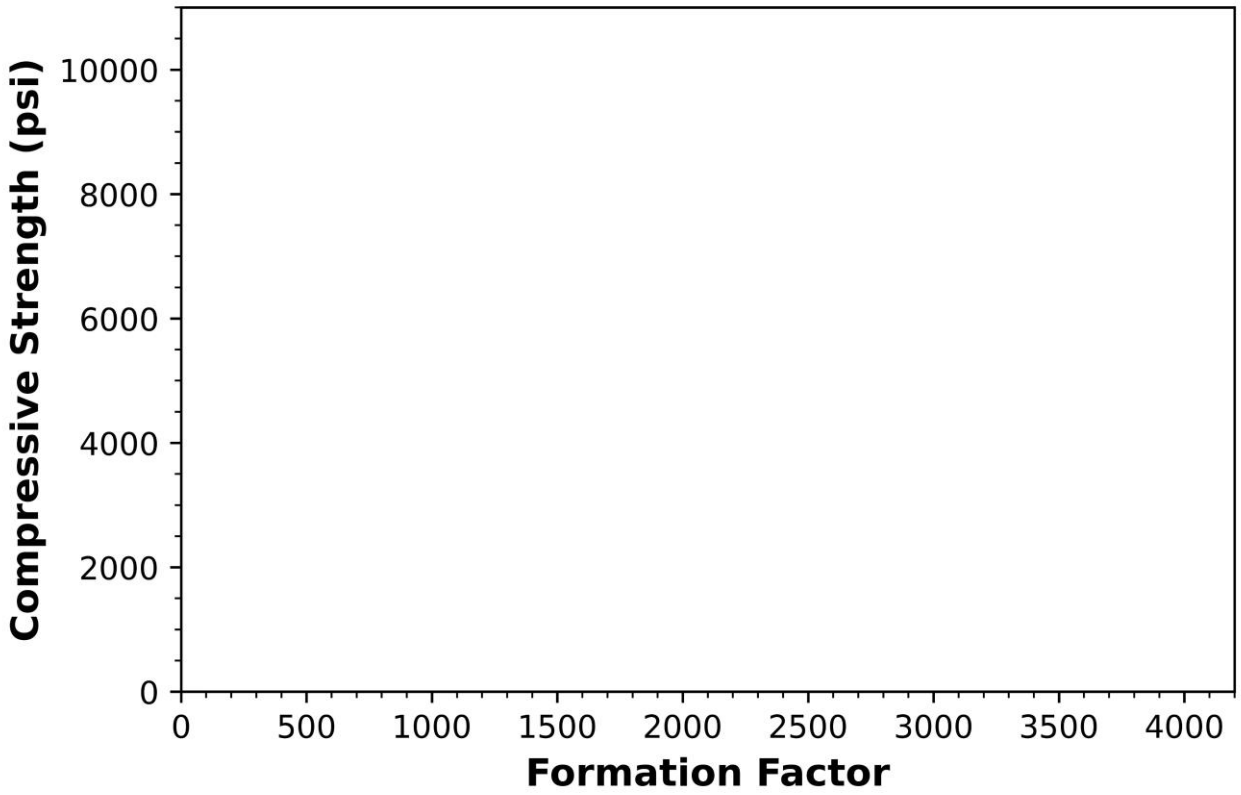
Qadri and Garg, *Case Studies of Con. Mat.* **2023**

Formation factor vs. compressive strength

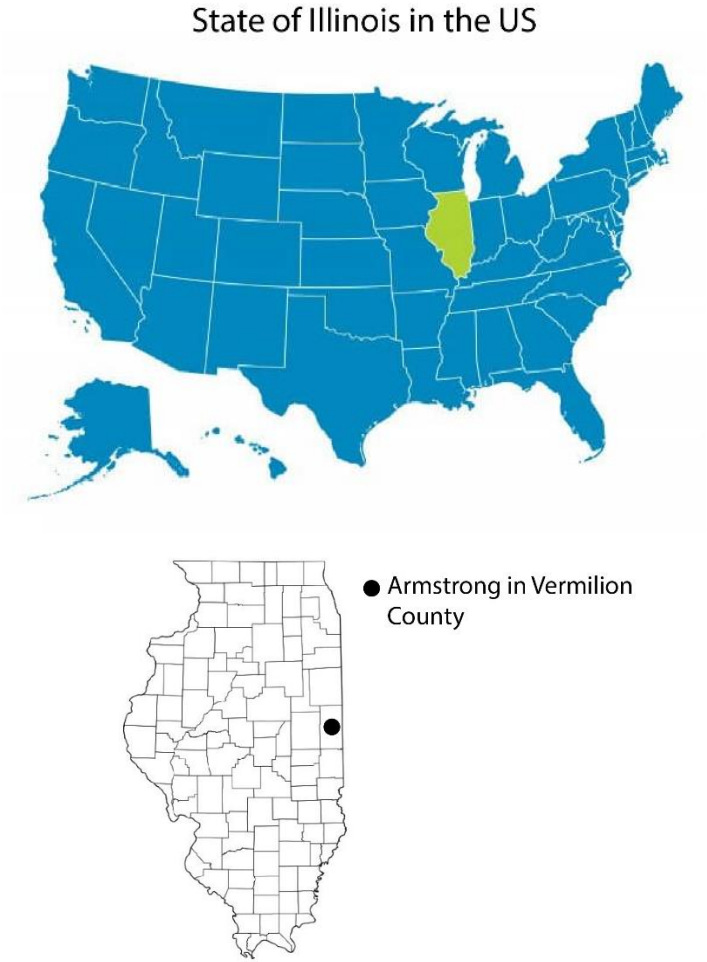
Lab data

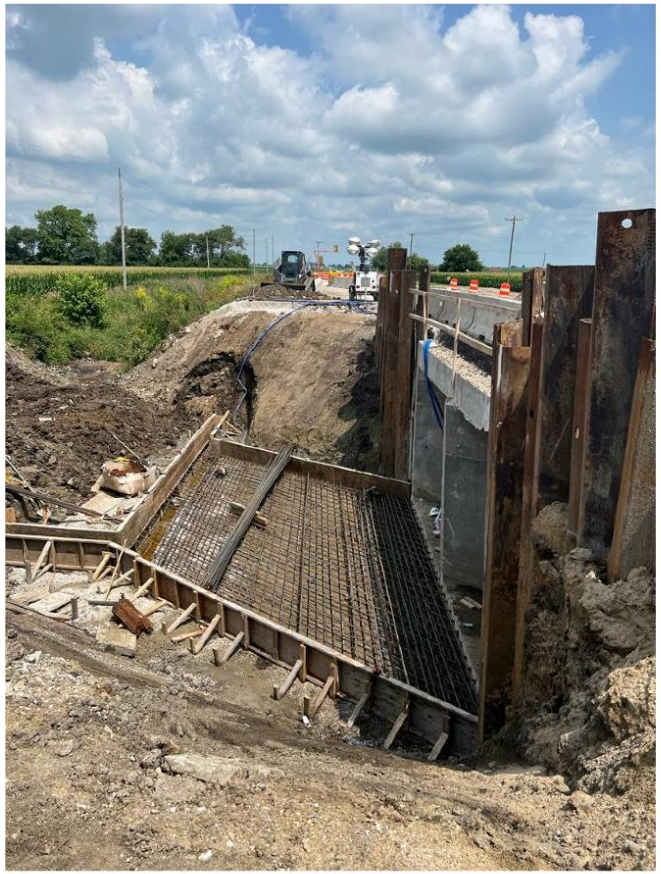


Field data



Field Implementation in Illinois





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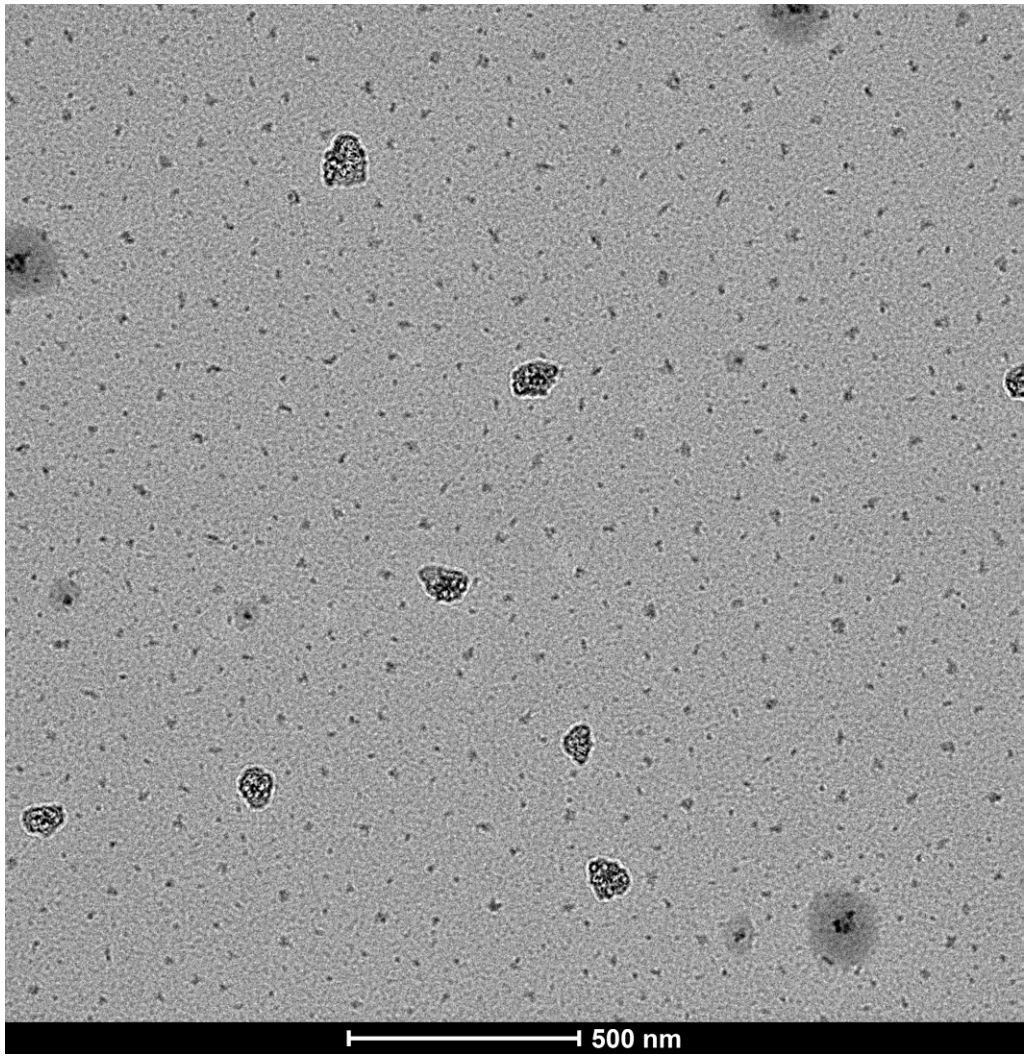
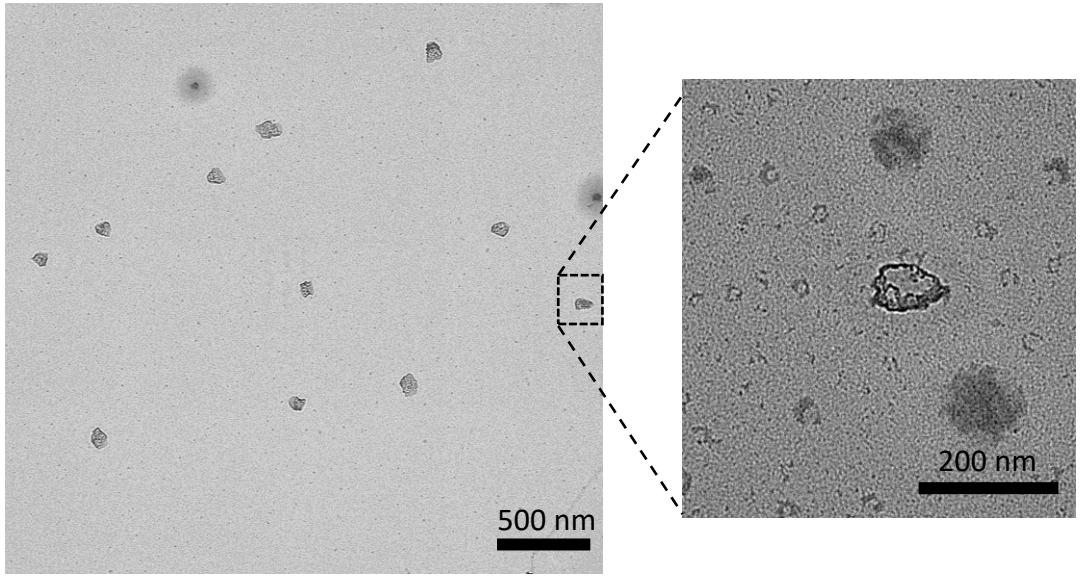
Some TEM images

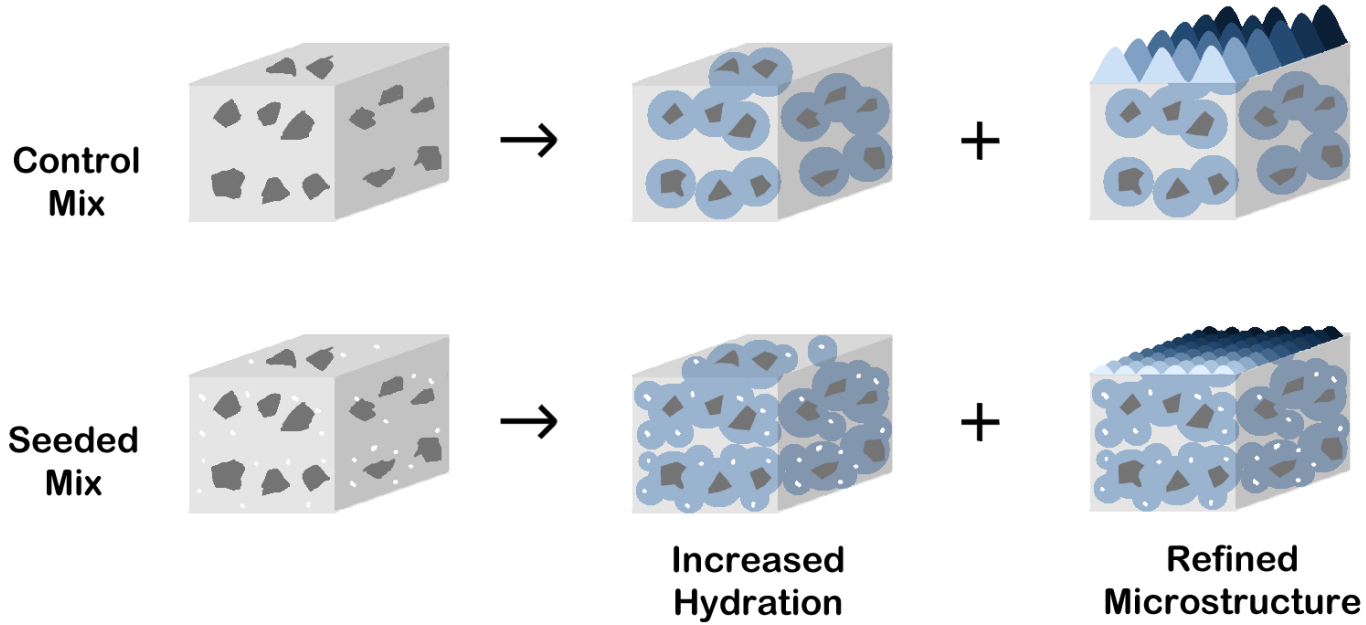




Contributions & Future Outlook

- C-S-H seeds affect the kinetics depending on the dispersion medium. Excess of PCE may cause set time retardation.

- Based on the Helium pycnometry and laser profilometry, there's evidence that C-S-H seeds refine the microstructure



- An application in the field proved the efficiency of using these seeds. Future work could be aimed at synthesizing and further finetuning such seeds

Qadri et al., *Mat. Today Com.* **2024**
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Acknowledgements

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garg.cee.illinois.edu

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